

Interior Lake Evaluations

by

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and

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April 2013

Alaska Department of Fish and Game

Divisions of Sport Fish and Commercial Fisheries



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Weights and measures (metric)		General		Mathematics, statistics		
centimeter	cm	Alaska Administrative Code	AAC	all standard mathematical signs, symbols and abbreviations		
deciliter	dL	all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.	alternate hypothesis	H _A	
gram	g	all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.	base of natural logarithm	<i>e</i>	
hectare	ha			catch per unit effort	CPUE	
kilogram	kg			coefficient of variation	CV	
kilometer	km	at compass directions:	@	common test statistics	(F, t, χ^2 , etc.)	
liter	L			confidence interval	CI	
meter	m			correlation coefficient (multiple)	R	
milliliter	mL	east	E	correlation coefficient (simple)	r	
millimeter	mm	north	N	covariance	cov	
Weights and measures (English)		south	S	degree (angular)	°	
	cubic feet per second	ft³/s	west	degrees of freedom	df	
	foot	ft	copyright	expected value	<i>E</i>	
	gallon	gal	corporate suffixes:	greater than	>	
	inch	in	Company	greater than or equal to	≥	
	mile	mi	Corporation	harvest per unit effort	HPUE	
	nautical mile	nmi	Incorporated	less than	<	
	ounce	oz	Limited	less than or equal to	≤	
	pound	lb	District of Columbia	logarithm (natural)	ln	
	quart	qt	et alii (and others)	logarithm (base 10)	log	
yard	yd	et cetera (and so forth)	etc.	logarithm (specify base)	log ₂ , etc.	
Time and temperature		exempli gratia		minute (angular)	'	
	day	d	(for example)	e.g.	not significant	NS
	degrees Celsius	°C	Federal Information Code	FIC	null hypothesis	H ₀
	degrees Fahrenheit	°F	id est (that is)	i.e.	percent	%
	degrees kelvin	K	latitude or longitude	lat. or long.	probability	P
	hour	h	monetary symbols (U.S.)	\$, ¢	probability of a type I error (rejection of the null hypothesis when true)	α
	minute	min	months (tables and figures): first three letters	Jan,...,Dec	probability of a type II error (acceptance of the null hypothesis when false)	β
	second	s	registered trademark	®	second (angular)	"
	Physics and chemistry		trademark	™	standard deviation	SD
		all atomic symbols		United States (adjective)	U.S.	standard error
alternating current		AC	United States of America (noun)	USA	variance	
ampere		A	U.S.C.	United States Code	population sample	Var var
calorie		cal	U.S. state	use two-letter abbreviations (e.g., AK, WA)		
direct current		DC				
hertz		Hz				
horsepower		hp				
hydrogen ion activity (negative log of)		pH				
parts per million		ppm				
parts per thousand	ppt, ‰					
volts	V					
watts	W					

REGIONAL OPERATIONAL PLAN SF.3F.2013.03

INTERIOR LAKE EVALUATIONS

by

Cal Skaugstad

and

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Alaska Department of Fish and Game, Division of Sport Fish, Fairbanks

Alaska Department of Fish and Game
Division of Sport Fish

April 2013

The Regional Operational Plan Series was established in 2012 to archive and provide public access to operational plans for fisheries projects of the Divisions of Commercial Fisheries and Sport Fish, as per joint-divisional Operational Planning Policy. Documents in this series are planning documents that may contain raw data, preliminary data analyses and results, and describe operational aspects of fisheries projects that may not actually be implemented. All documents in this series are subject to a technical review process and receive varying degrees of regional, divisional, and biometric approval, but do not generally receive editorial review. Results from the implementation of the operational plan described in this series may be subsequently finalized and published in a different department reporting series or in the formal literature. Please contact the author if you have any questions regarding the information provided in this plan. Regional Operational Plans are available on the Internet at: <http://www.adfg.alaska.gov/sf/publications/>

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This document should be cited as:

Skaugstad, C. and A. Behr. 2013. Interior lake evaluations. Alaska Department of Fish and Game, Division of Sport Fish, Regional Operational Plan ROP.SF.3F.2013.03, Fairbanks.

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SIGNATURE PAGE

Project Title: Interior Lake Evaluations

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Division, Region, and Area: *Sport Fish, Region III, Fairbanks*

Project Nomenclature: Federal Aid (F-10-28 through 29; E-3-01); SWG (T-10-6); and RSA from DOT

Period Covered: 1 March 2013–30 April 2014

Field Dates: 1 March–15 November 2013

Plan Type: Category II

Approval

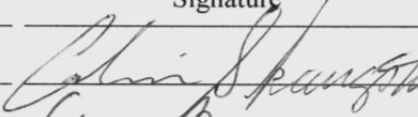
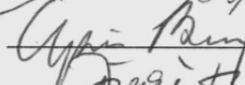
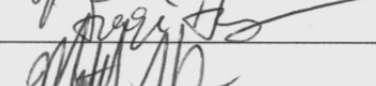
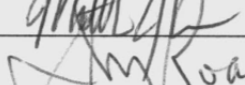
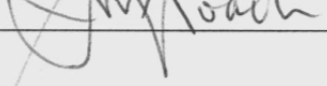
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PURPOSE

The Alaska Department of Fish and Game (ADF&G) Division of Sport Fish conducts lake evaluations on both stocked and wild systems throughout Region III. Lakes to be sampled during the 2013 field season fall into three categories (with three separate funding sources): *Stocked Fishery Evaluations* (Federal Aid-FA), *New Lake Evaluations* (State Wildlife Grant-SWG), and *Ambler Road Lake Surveys* (Alaska Department of Transportation-DOT). The study design and methods used to evaluate lakes in each of these categories are similar in nature and therefore summarized in one Operational Plan. Fish population, water quality, and bathymetric data will be collected.

Stocked Fishery Evaluations are needed to evaluate and adjust current stocking strategies and fish hatchery production, update informational handouts, and provide the public with up to date information regarding fishing opportunities.

New Lake Evaluations and *Ambler Road Lake Surveys* are needed to identify new sport fishing opportunities and to collect baseline information on water bodies with limited or no existing information. Managers need baseline information to develop management plans, assess the impacts of current or proposed development, issue permits, and monitor changes in aquatic systems over time.

Results from these monitoring projects will be made available to managers and anglers in a Fishery Data Series (FDS) report containing 2011–2013 data. The department also disseminates this information through publications such as the *Guide to Stocked Fisheries*, through the Fish and Game internet website, the Alaska Lake Database (ALDAT), and in informational handouts.

BACKGROUND

STOCKED FISHERY EVALUATIONS

Stocked Fisheries Management Plan

In 2004, the Board of Fisheries (BOF) adopted two new general management plans for stocked fisheries within Region III (5 AAC 70.065 and 5 AAC 52.065, 2004). The plans outline three management approaches with corresponding objectives and regulations.

- Regional Management Approach. Under the regional management approach, stocked fisheries will be managed so that there will be a reasonable expectation of high catch rates and harvesting a daily bag limit. The bag and possession limit is 10 fish in combination of all stocked species, and only one of those fish may be 18 inches (457 mm TL) or greater in length. The fishing season is open year round and bait may be used.
- Conservative Management Approach. Under the conservative management approach, stocked fisheries will be managed so that there will be a reasonable expectation to catch a daily bag limit with a reasonable chance of catching fish 18 inches (457 mm TL) or greater in length. The bag and possession limit is five fish in combination of all stocked species, and only one of those fish may be 18 inches (457 mm TL) or greater in length. The fishing season is open year round and bait may be used.
- Special Management Approach. Under the special management approach, stocked fisheries will be managed so that there will be a high probability of an angler catching

more than one fish a day that is 18 inches (457 mm TL) or greater in length. When considering a proposal regarding this management approach, the board should consider taking the following actions:

- (1) limit fishing to
 - (A) catch-and-release fishing;
 - (B) fly fishing;
 - (C) trophy fishing, which means that a fish retained must be 18 inches or greater in length;
- (2) establish seasonal periods when fishing is closed or is restricted to catch-and-release fishing; or,
- (3) establish a bag limit of one fish, 18 inches (457 mm TL) or greater in length, or another appropriate bag and size (length) limit.

Future Stocked Fisheries Program Assessment

In order to more directly assess the objectives outlined in the stocked fisheries management plan, ADF&G needs to focus on anglers to assess their understanding of the three management approaches, to quantify their expectations and desires, and to determine whether these expectations are being met. This work should be conducted after the Ruth Burnett Sport Fish Hatchery in Fairbanks is producing fish at a preferred stocking capacity and after the stocked fish populations have stabilized, the earliest being 2014. In recent years, ADF&G has stocked fish at levels that are less than desirable and fishery managers have been faced with fluctuating numbers of fish, sizes, and production schedules that do not meet angler needs. Any efforts to survey anglers now will only serve to evaluate a changing interim condition. But, it is prudent to begin planning such a survey now.

Until hatchery production improves, and stocked fish populations stabilize, we use an indirect (but reasonable) evaluation method to evaluate specific stocked fish populations in the Tanana River Management Area (TRMA) and Upper Copper Upper Susitna Management Area (UCUSMA). These methods are outlined below.

Current Stocked Fish Population Assessments

Management Objectives and Standards

Each management approach lists general objectives for numbers and sizes of fish that anglers should have a reasonable expectation to catch and harvest. To meet these objectives we designed population structures (Skaugstad *In prep*) and implemented stocking schemes that we expect will provide a reasonable opportunity for an angler to catch and harvest the number and size of fish described in each approach.

From these population structures we determined standards for each management approach by calculating the mean length for the portion of the population structure within an appropriate size group (Appendix A). For a fishery to be considered a success the observed mean must be equal to or greater than the standard.

Information Needs

Fish Populations

Fishery managers have identified two levels of sampling to obtain fish population information needed to periodically evaluate stocked fisheries and determine if reasonable opportunity is being provided. The first level requires unbiased length information to determine if stocking strategies have created the desired population structures, which typically have been defined for most rainbow trout populations. This information is obtained using sampling methods that are described in the *Population Length-Age Structure* section of this plan.

The second level requires only basic information about the presence, size range, and general health of fish populations to determine if objectives are met. This information is collected using sampling methods to observe fish populations in several lakes each year, to determine if fish survived winter, and to make a general assessment of a population's overall status. Sampling methods used to acquire this information are described in the section *Basic Population Information*.

Fishery managers will use the information from both levels of sampling to adjust stocking methods and fish hatchery production. After examining the information managers may decide that more accurate and detailed research on fish populations or habitat is warranted.

Water Quality

Water quality data are needed to help biologists and managers determine stocking strategies and interpret sample results.

We use parameters such as temperature and dissolved oxygen to select suitable species for stocking and to determine the size and number of fish to stock. Because different species have different thermal tolerances and habitat niches the data we collect helps us identify available habitat and then select the stocked species that is best suited for that environment.

We also use water quality data to help us interpret why a population length-age structure does not conform to our expectation. Water quality parameters can influence fish growth and abundance of prey, consequently influencing survival and the population's length-age structure. By examining a population length-age structure and using ancillary information about water quality, we can often identify likely explanations for differences between the actual and desired length-age structures. Managers and biologists can then make informed and suitable adjustments to the stocking scheme. Occasionally, we may discover that for some lakes the desired population structure is not realistic due to the natural limitations of the system.

Bathymetric Maps

Bathymetric maps are used to describe a lake's physical characteristics. A bathymetric map is used to calculate several characteristics such as surface area, maximum length and width, mean depth, maximum depth, shoreline length, shoreline development, and volume that are crucial to understanding how a lake system functions. The shape and structure of a lake basin strongly influences the lake's biotic and abiotic characteristics. We use a lake's morphometric features, in combination with other limnology features such as prevalence of aquatic vegetation, to predict seasonal thermal and dissolved oxygen profiles and the likelihood of winter-kill events. We use this information to select suitable species and methods for stocking fish.

Lake Selection

Currently, there are 124 lakes in the Stocked Fisheries Program (SFP) in Interior Alaska. This number fluctuates annually as lakes are added to or removed from the program. Because research and management resources are limited, only 10 to 20 lakes can be examined each year.

The criteria for selecting lakes for study include: 1) the importance of the information for management needs; 2) the number of public inquiries or requests for development of a fishery, or for information about the lake or species present in the lake; and, 3) the desire to visit most stocked lakes at least once every 5–10 years to assess fish populations and lake habitat.

Fish populations in nine stocked lakes in the TRMA and UCUSMA will be examined during the 2013 field season (Table 1, Figure 1–3); all lakes are in the Regional Management category. Basic population information is needed for fish populations in six study lakes and length-age information is needed for populations in three lakes (Table 1). Desired population structures used to perform length-age analysis are shown in Appendix A. Water quality data will be collected on all nine lakes (Table 1). Lake locations are shown in Figure 1–3 and recent stocking histories for each lake are listed in Appendix B.

NEW LAKE EVALUATIONS (SWG)/AMBLER ROAD LAKE SURVEYS (DOT)

These projects are designed to collect baseline information about the current status of aquatic communities and habitat throughout Alaska over time. The information needed for new lake evaluations is nearly identical to that which is collected during *Current Stocked Fish Population Assessments*. We will collect data to determine fish species present, evaluate water quality, and create bathymetric maps.

For many lakes in Interior Alaska species and habitats have not been investigated, documented, or, in some cases, sampled in over 50 years. Some of these aquatic systems are in areas that are or will be impacted by current and proposed resource exploration and development. Exploration and development activities include the extension of the Alaska railroad, proposed roads, resource extraction, and more extensive and intensive use of military training areas. Resource managers need a better understanding of the distribution and habitat use of freshwater fishes within Interior Alaska in order to maintain healthy aquatic resources that will sustain responsible use and development.

Fish information, water quality, and bathymetry data are used by state and federal agencies when developing management plans, assessing the impacts of current or proposed development, issuing permits, and monitoring changes in aquatic systems over time. From these observations managers can judge if natural or human activity is resulting in changes to fish distribution, size, abundance, and community structure. In addition to documenting species and habitat, these sampling activities will also help ADF&G Sport Fish area managers identify new angling opportunities.

Information Needs

Fish Populations

Basic population information is needed to document native species present, their size range, and their overall condition. This information helps biologists and managers identify critical habitats, fish distributions, the current status of fish communities, and fish populations that require more detailed investigation. Fish presence information is also needed to address public stocking

requests and inquiries about wild systems and angling opportunities. Sampling methods used to acquire this information are described in the section *Basic Population Information*.

Water Quality

Water quality data is needed to identify the types and limits of habitat used by different fish species, to document baseline levels, to monitor habitat changes over time, and to plan more detailed fish or habitat research. Water quality information such as dissolved oxygen and temperature is useful when evaluating fish species presence or absence and is used to establish fish sampling protocol such as appropriate capture gear and sample locations.

Bathymetric Maps

Bathymetric maps are used to calculate several characteristics such as surface area, maximum length and width, mean depth, maximum depth, shoreline length, shoreline development, and volume. These characteristics are also useful when identifying habitat needs, usage, and limitations. Documentation of the physical attributes of a lake (e.g., surface hectares) can be used to monitor environmental changes, such as lake succession declining water level, and identifying attributes (e.g., deep vs. shallow) that may limit fish presence or habitat. Additionally, volumetric calculations from bathymetric data are often required before permits for resource use and extraction are issued.

Lake Selection

Lakes are selected for sampling at an area manager's request. Sample lakes are prioritized based on 1) the importance of the data for management needs (i.e., proposed development or to issue permits); 2) input from the public; and, 3) the available budget and associated project costs.

Five lakes have been selected for *New Lake Evaluations (SWG)* in the TRMA and UCUSMA (Table 1, Figure 1–3). Fish presence, water quality, and bathymetric data will be collected at Skate Lake and bathymetric data will be collected at the remaining locations as time, personnel, and budget allows.

Four lakes have been selected for *Ambler Road Lake Surveys (DOT)* in the Northwest and Yukon River Management Area (Table 1, Figure 4). For these lakes, fish presence, water quality, and bathymetric data will be collected.

Table 1.–Lake description and data requirements for 2013 lake sampling. Stocked Fisheries Program (SFP), State Wildlife Grant (SWG), and Ambler Road Lake Surveys (DOT) assessment in 2013.

Lake/Date	Management	Hectare (Acre)	Fish	Native Species	Previously Stocked	Water	Map	Project
Northwest Management Area								
AR7	n/a	10.9 (27)	Basic	Unknown	None	Yes	Yes	DOT
Avaraart Lake	n/a	276.2 (682)	Basic	Unknown	None	Yes	Yes	DOT
Norutak Lake	n/a	1691.2 (4179)	Basic	Unknown	None	Yes	Yes	DOT
WL730	n/a	151.3 (3836)	Basic	Unknown	None	Yes	Yes	DOT
Tanana River Management Area								
<i>Fairbanks</i>								
Harding Lake	Special	1,066 (2,633)	None	BB, LCI, NP,	AC, GR, SS, SF, LT,	No	Yes	SWG
Hidden Lake	Regional	7.3 (18)	Basic	LCI, LNS, NP	AC, GR, LT, RT	Yes	No	SFP
Manchu Lake	Regional	17.4 (43)	Basic	None	AC, SS, SF, RT	Yes	No	SFP
North Pole Pond	Regional	6.9 (17)	Basic	None	AC, GR, KS, SS, RT	Yes	No	SFP
<i>Delta</i>								
Fielding Lake	n/a	673.4 (1664)	None	LT, GR, WF,	None	No	Yes	SWG
Four Mile Lake	Regional	40.5 (100)	Length-age	None	AC, SS, SF, LT, RT	Yes	No	SFP
Healy Lake	n/a	Unknown	None	Unknown	BB, NP, HBWF, LCI	No	Yes	SWG
North Twin Lake	Regional	8.9 (22)	Basic	SSC	KS, SS, LT, RT	Yes	No	SFP
Skate Lake	n/a	Unknown	Basic	Unknown	None	Yes	Yes	SWG
South Twin Lake	Regional	8.1 (20)	Basic	SSC	KS, SS, RT	Yes	No	SFP
Upper Copper Upper Susitna Management Area								
Gergie Lake	Regional	24.3 (60)	Length-age	GR, LNS	RT	Yes	No	SFP
Sculpin Lake	Regional	76.9 (190)	Length-age	SSC	AC, SS, RT	Yes	No	SFP
Silver Lake	Regional	202.3 (500)	Basic	SSC	SS, RT	Yes	No	SFP
Summit Lake	n/a	Unknown	None	LT, BB, GR,	LT	No	Yes	SWG
Yukon River Management Area								
AR5	n/a	38.8 (96)	Basic	Unknown	None	Yes	Yes	DOT
AR6	n/a	1.9 (5)	Basic	Unknown	None	Yes	Yes	DOT
AC=Arctic char	<i>Salvelinus alpinus</i>		LNS=longnose sucker	<i>Catostomus catostomus</i>		RWF=round whitefish	<i>Prosopium cylindraceum</i>	
GR=Arctic grayling	<i>Thymallus arcticus</i>		LT=lake trout	<i>Salvelinus namaycush</i>		SF=Sheefish	<i>Stendous leucichthys nelma</i>	
HBWF=hump back whitefish	<i>Coregonus oidschian</i>		NP=northern pike	<i>Esox lucius linnaeus</i>		SS=coho salmon	<i>Oncorhynchus kisutch</i>	
KS=Chinook salmon	<i>Oncorhynchus tshawytscha</i>		RS=sockeye salmon	<i>Oncorhynchus nerka</i>		SSC=slimy sculpin	<i>Cottus cognatus</i>	
LCI=Least Cisco	<i>Coregonus said</i>		RT=rainbow trout	<i>Oncorhynchus mykiss</i>				

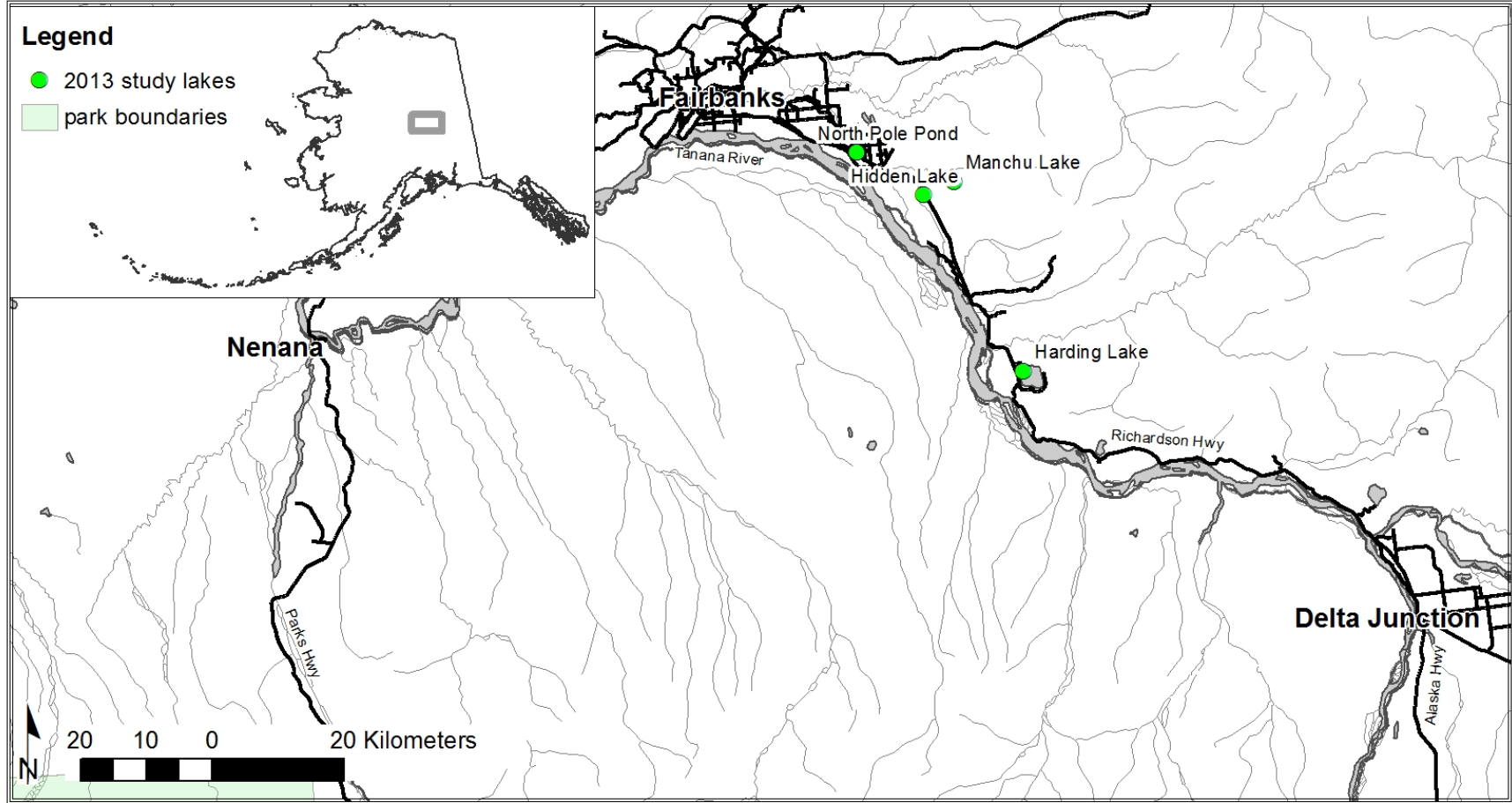


Figure 1.—Location of Lower Tanana River Management Area lakes (near Fairbanks) to be sampled in 2013.

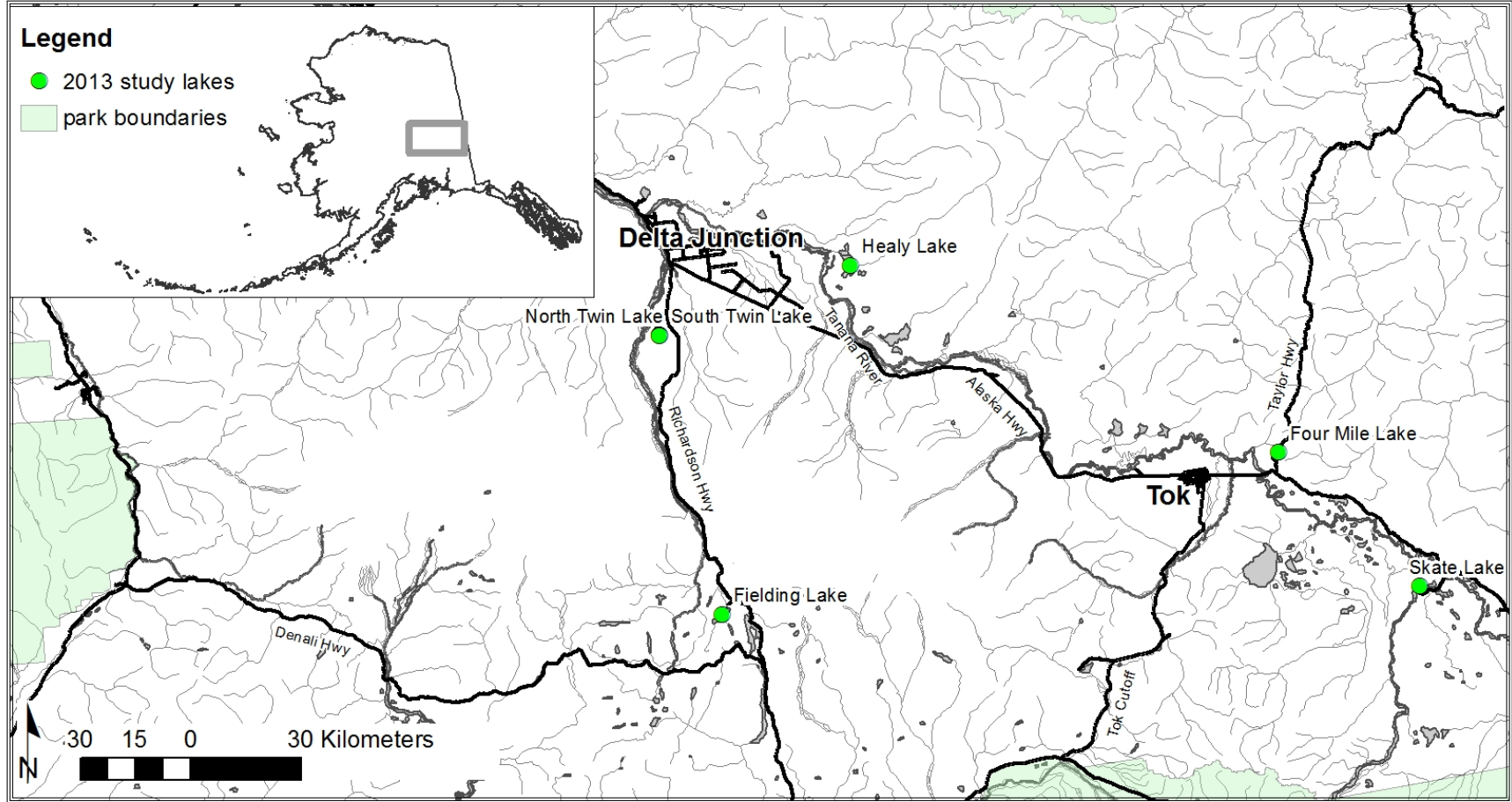


Figure 2.—Location of Upper Tanana River Management Area lakes (near Delta) to be sampled in 2013.

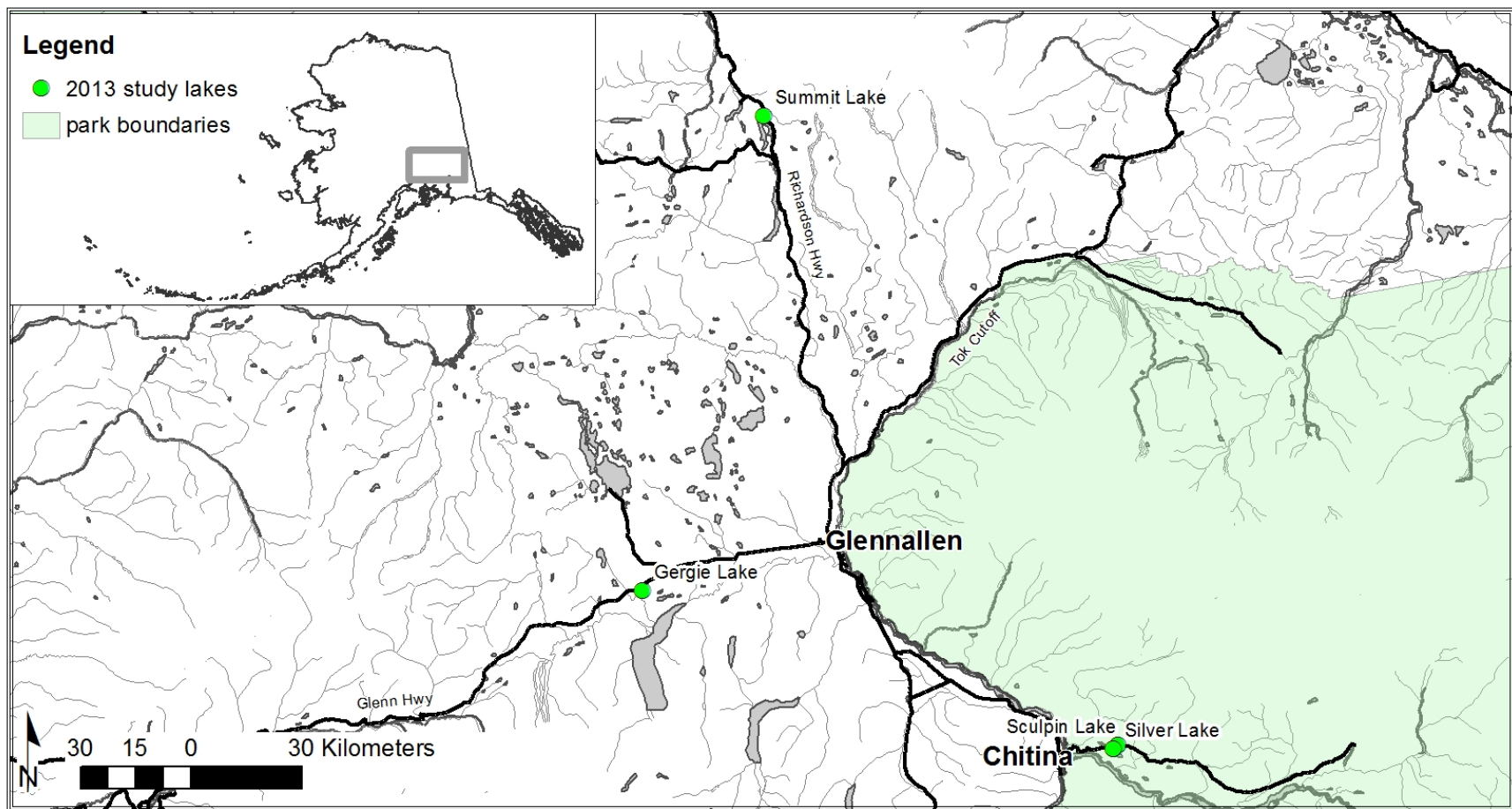


Figure 3.—Location of Upper Copper Upper Susitna River Management Area lakes (near Glennallen) to be sampled in 2013.

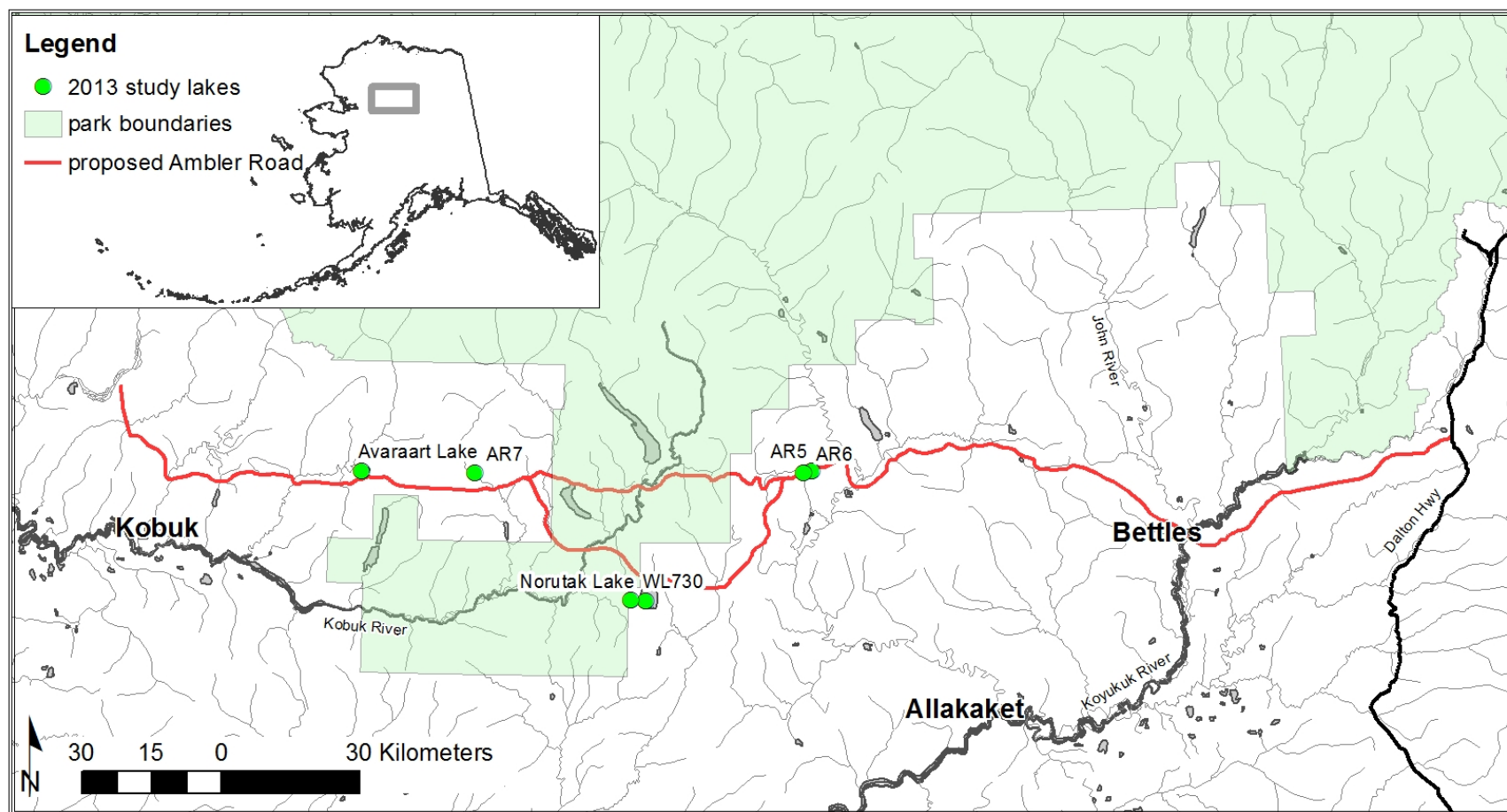


Figure 4.—Location of Yukon River and Northwest Management Area lakes to be sampled in 2013.

OBJECTIVES

POPULATION LENGTH-AGE STRUCTURE

- Management Objective 1: Determine if rainbow trout populations are achieving the management length and age structures listed in Appendix A.
- Research Objective 1: Test the null hypothesis that mean length of rainbow trout within defined length categories (listed by fishery in Appendix A) does not differ from the management value with 90% power of rejecting the null hypothesis if the true mean length differs from the management value by more than 10% using $\alpha = 0.10$.

BASIC POPULATION INFORMATION

- Management Objective 2: Provide fishery managers and anglers with current information about fish species present, size range, overall appearance and condition, and document whether fish survived winter in the selected lakes.
- Research Objective 2: Survey selected lakes to determine fish species present, characterize the size range of the fish captured, and describe the overall appearance and condition of captured fish.

WATER QUALITY

- Management Objective 3: Describe select physical and chemical properties during fish sampling (June, August, or September).
- Research Objective 3: Measure water clarity, temperature, dissolved oxygen, pH, total dissolved solids, specific conductivity, and alkalinity.

BATHYMETRIC DATA AND OTHER LAKE CHARACTERISTICS

- Management Objective 4: Collect morphometric data.
- Research Objective 4: Survey the lake bottom to obtain depth, longitude, and latitude data for producing bathymetric maps;
- Research Objective 5: Describe the lake watershed and the immediate surroundings, such as tree/shrub cover, and inlets and outlets; and,
- Research Objective 6: Photograph the lake and surrounding area from north and south locations and, if flown into a lake, take aerial photographs of the lake and surrounding area.

METHODS

POPULATION LENGTH-AGE STRUCTURE

Study Design

The length-age structure of rainbow trout populations in specified stocked lakes will be estimated using single-sample capture events. The population length structure will serve as an

indicator of the population age structure. Scales will not be collected for aging because hatchery reared fish often have false annuli that confound accurate aging. All sampling will be conducted when water temperature at 1 m below the surface is < 18°C.

Sampling Methods

Capture Gear

Fyke nets will be set near shore on the lake bottom in 1m to 2 m of water. The location and spacing of the nets will be left to the crew leader's judgment. Fyke nets have square openings that are either 0.9 m or 1.2 m per side, the body length from opening to cod end is about 5 m, hoop size is 0.9 m in diameter, and mesh size is 9 mm². Wings measuring 7.5 m long by 1.2 m deep are attached to each side of the frame at the open end. The net body will be positioned parallel to shore and the wings will be set to form a "V". Each fyke net will be pulled taut from the cod end and held in position with a weight.

Tangle nets will be set perpendicular to shore in water deeper than 2 m and will only be used when the crew is on site to reduce injury to fish. Tangle nets measure 45 m long by 5.4 m deep and are made of 13 mm bar fine thread monofilament. Mesh size is small to ensure that fish will be captured by entanglement around the mouth and not by the gill covers. One of two types of tangle nets will be used. One net is a "floaters" (the float line buoyancy is greater than the weight of the lead line); the other net is a "sinker" (the lead line is weighted to overcome the buoyancy of the float line). The floaters has a triple float line and 13.6 kg lead line. The sinker has a double float line and a 31.75 kg lead line. Tangle nets will be checked every 30 minutes. The crew leader will adjust the time interval after assessing captured fish.

Sampling Schedule

The amount of capture gear and the duration of sampling projects will be based on lake size (Table 2).

Table 2.—Sampling effort according to lake size.

Hectare (Acre)	Nights	Fyke Nets	Tangle Nets	Minnow Traps ^a
0 to 20 (50)	1	4	1	4
>20 to 40 (100)	2	4	1	4
>40 to 200 (500)	3	4	2	4
>200 to 400 (1,000)	3	6	2	6
>400 (1,000)	3	8	2	6

^aMinnow traps are not used to sample stocked lakes; however, they are used during new lake evaluations and are referenced later in this plan.

Marking

If nets are fished for more than one night, fish captured for the first time regardless of gear type will be marked by removing a half circle of tissue from the trailing edge of the upper lobe of the caudal fin. The mark will be made with a paper punch that produces a 7 mm diameter circular hole. This marking method is desired because the mark is easily recognized, the amount of removed tissue is small, and the mark usually regenerates within a year. Other marking methods

that use total fin removal or Floy™ tags are permanent and diminish the appearance that anglers desire for fish when they reach larger size.

Sample Size: Hypothesis Test of Mean Lengths (Research Objective 1)

Mean lengths will be estimated within specified length groups. Minimum sample sizes to satisfy the precision criteria for Objective 1 are determined by calculating the population mean and variance by length group for each lake using the management length distributions displayed graphically in Appendix A. Minimum sample sizes for estimating mean length for each length group g ($g = 1$ to G) were calculated using (Zar 1984):

$$n_g = \frac{s_g^2}{\delta_g^2} (t_{\alpha(1,2),v} + t_{\beta,v})^2 \quad (1)$$

where:

n_g is the minimum sample size for group g ;

t are critical values from Student's t-distribution;

v is the degrees of freedom;

s_g^2 is the population sample variance of the distribution of management lengths in g ;

and,

δ_g is the minimum detectable length difference (25 mm) of management lengths in g .

The calculated minimum sample sizes for each lake for length group g are shown in Table 3.

Table 3.—Minimum sample size required to estimate mean length in a defined length group of rainbow trout in study lakes.

Lake	Predicted Abundance	Sample Size (n)
<i>Tanana River Management Area</i>		
Four Mile Lake	216	6
<i>Upper Copper Upper Susitna Management Area</i>		
Gergie Lake	523	8
Sculpin Lake	216	6

The predicted abundance for each lake (Table 3) is based on a preferred stocking scheme and estimates of survival for age-1 through age-5 as described in Skaugstad (*in prep*). Typically, less than 10% of a population is handled during single-sample capture events. Proportionally more effort will be directed towards smaller populations where minimum sample size exceeds 10% of the population.

Data Collection

All data will be recorded in field notebooks or on pre-made forms (Appendix C). Prior to field work the crew leader will obtain a lake map from files or generate a map from a computer mapping application. Bathymetric markings are preferred if available. The crew leader will provide one copy for each day of field work plus two extra copies.

Every day, capture gear type (fyke nets, tangle nets, sport gear), capture gear locations (waypoint: WGS 84 ddd.ddddd), set depths (m or ft), set and pull dates (MM/DD) and times (military), and temperature (to the nearest 0.10°C) will be recorded on a data form (Appendix C). Also, a new lake map will be used each day to record capture gear type and locations.

Fish length (nearest mm FL), visual inspection of fish body appearance (thin vs. normal), and external signs of disease and parasites along with any tagging data (recapture) will be recorded on the field form as described in Appendix C.

The crew leader will also keep a detailed, daily field journal in a “Rite-in-the-Rain[®]” notebook. An important goal is to identify conditions that may substantially affect the probability of capture during a sampling event. Information collected should include:

- 1) Major weather events (rain, hail, high wind) and water conditions (waves, clarity); and,
- 2) Any other relevant details or observations, such as fish behavior (spawning, feeding), fish health, and note the type of aquatic invertebrates present (identify to order if possible).

Data Reduction

Data will be transferred from notebooks and field data forms to Microsoft Excel worksheets for analysis and archival. The worksheets will provide a complete history of capture and biological data for each fish. All data and descriptive information in notebooks and field data forms will be examined for obvious errors, corrected, and entered into a Microsoft Excel spreadsheet immediately following the field collection period. After entering the data into the spreadsheet, a battery of data summaries will be performed to identify obvious transcription errors (i.e., lengths smaller or larger than what was observed in the field or GPS coordinates that lie outside the lake perimeter). Errors will be corrected when possible or the data will be excluded from further analysis. Additional columns may be added for clarity and a glossary of all column headings will be provided in a text box along with a brief project description. Final copies of worksheet files will be provided with the completed report when it is submitted for printing to be archived in the Sport Fish Division Docushare repository. At that time, a file name and directory will be assigned, which will be included as an appendix in the final report. All fish data will also be stored in the Alaska Lake Database (ALDAT) accessible at:

http://www.adfg.alaska.gov/SF_Lakes/.

Data Analysis

Length Frequency Distributions

The *histogram* function in Excel will be used to count the number of rainbow trout having lengths that fall within 10 mm length categories. Length categories will start at 0 mm and increase by 10 mm intervals (e.g., 0 to <10 mm, 10 to <20 mm, etc.) The last length category for a data set will include the largest fish. This information will be used to create a column chart to illustrate the population length frequency distribution (LFD).

The histograms will be used to count the number of fish having lengths that fall within a defined length category: between ≥ 200 mm and < 350 mm or ≥ 350 mm (depending on the management category of the lake). Additionally, the LFD chart will be used to visually identify length-age cohorts within the population and to help determine the mode for each cohort. For the fisheries that are stocked on alternate years the length-age cohorts can often be identified because two age

cohorts are separated by a missing age cohort. However, when the fishery is stocked every year, length-age cohorts are not easily identified. Faster growing fish in a younger cohort can be larger than the slower growing fish in an older cohort. As a result, the length-age cohort LFDs overlap making it difficult to distinguish length modes and to determine the number of fish in each cohort.

Estimates of Mean Lengths

Mean lengths of fish captured and corresponding sampling variances within length categories described in Appendix A will be calculated using standard sample summary statistics (Cochran 1977).

Hypothesis Test of Management Means

The observed mean lengths from collected data will be compared to the standards for length categories (Appendix A) using a one tailed t-test (Zar 1984).

Assumptions and Bias

One potential concern with using data from this single-sample study design is that inadequate data are collected to evaluate size bias during sampling. This topic is addressed in Appendix D.

Other Biological Data

The number of fish classified as having external signs of disease, parasites, or a thin body will be summarized as follows: x/n (x number of fish were classified with the condition out of a sample size of n fish).

BASIC POPULATION INFORMATION

Study Design

This sampling procedure is designed to collect minimal but sufficient data to answer basic questions posed by fishery managers. This approach is appropriate because costs are minimized which allows a large number of fisheries to be sampled during the year.

We will use single-sample capture events to identify fish species present and to describe the length distribution and overall health of captured fish. Fyke nets and tangle nets will be used to capture fish species in stocked lakes. Fyke nets, tangle nets, and minnow traps will be used to sample fish populations in lakes that are not stocked.

Sampling Methods

Capture Gear

General descriptions and methods for using fyke nets and tangle nets are described in *Population Length-Age Structure – Sampling Methods*.

Minnow traps will be used in both near shore and offshore areas. Lake depth at each set location will be recorded. Set and pull times will be noted so that sampling effort is available. Minnow traps are 22 cm diameter and 42 cm long with an inward pointing funnel at each end. Traps are made of 6 mm wire mesh and will be attached to a vertical line that has a float on one end and a weight on the other, positioned horizontally in the water column, and baited with unsalted salmon roe or raw shrimp.

Sampling Schedule

The amount of capture gear and the duration of sampling projects will be based on lake size as outlined in the *Population Length-Age Structure* section of this plan (Table 2). The amount of capture gear may be adjusted to accommodate logistical constraints and reduce transportation costs when sampling in remote areas accessible only by aircraft.

Data Collection

The procedures described in *Population Length-Age Structure–Data Collection* will be followed.

Data Reduction

The procedures described in *Population Length-Age Structure–Data Reduction* will be followed.

Data Analysis

Sampling data will be summarized to show species present and size range (smallest and largest fish by species). LFDs plots will be generated when 10 or more fish of the same species are captured. For stocked lakes, when data are sufficient ($n \geq 15$), statistical analyses on rainbow trout will be performed following procedures describe for *Population Length-Age Structure*.

WATER QUALITY

Study Design

Sampling will be conducted at each study lake during fish sampling (June, August, or September) and during midsummer (July) and late winter (March) if time permits. These times were selected because environmental conditions often approach critical biological limits and fish are physically stressed. Summer water temperatures normally peak in most lakes during July (LaPerriere et al. 2003a) and dissolved oxygen levels can fluctuate dramatically within the course of a single day. High temperatures and low dissolved oxygen levels approach and may possibly exceed critical limits for some game fish species.

In northern latitude lakes, increasing length of time of ice and snow cover can reduce the contribution of oxygen by photosynthetic organisms and prolong the depletion of the oxygen reservoir by decomposers (LaPerriere et al. 2003b; Horne and Goldman 1994; Wetzel 1975; Danylchuk and Tonn 2003). These conditions increase the likelihood of winterkill where fish die due to low levels of dissolved oxygen.

Sampling Methods

Physical and chemical properties will be measured at a minimum of two stations in each lake. One station will be situated at the maximum depth of each major basin present in the lake. If there is only one basin, the second station will be located equal distance between the maximum depth and nearest shore (along the long axis of the lake; Koenings et al. 1987). A *YSI Incorporated Environmental Monitoring System 600XLM Sonde* or *Hydrolab MS5 Sonde* will be used to measure temperature, pH, dissolved oxygen, percent dissolved oxygen, specific conductivity, and total dissolved solids. Methods for operating the instruments will follow procedures described in the appropriate instruction manual. A 1-L sample of lake water will be taken over the deepest basin from a depth of 0.3m (1ft) and later titrated at room temperature to determine total alkalinity. Water transparency will be measured as the average of the depths that

a Secchi disk disappears and reappears as it is lowered and raised in the water (Koenings et al. 1987).

Data Collection

Lake name (location), lake type (glacial, organically stained, or clear-water), GPS coordinates, date, time, and weather conditions (e.g., cloud cover, air temperature) will be noted on a field data sheet (Appendix C). Water temperature, dissolved oxygen, percent dissolved oxygen, specific conductivity, pH, total dissolved solids, and oxidation reduction potential (ORP) readings will be recorded at 0.5 m intervals from the surface down to 5 m, and then at 1 m intervals until the lake bottom is reached. The depths where a Secchi disk disappears and reappears in the water will be recorded. Lake water color will be visually assessed in the field as clear, ferric, glacial-high turbidity, glacial-low turbidity, humic, or muddy (Table 4).

Table 4.—Descriptions of water color.

Code	Description	Definition
CLR	Clear	Transparent water, or nearly so.
FER	Ferric	Rust- (orange) stained.
GHT	Glacial, High Turbidity	High turbidity waters (visibility \leq 30 cm (12 in) typical of streams originating directly from glaciers (e.g., Matanuska River).
GLT	Glacial, Low Turbidity	Low turbidity waters (visibility $>$ 30 cm) typical of systems with large lakes (settling basins) below glacial discharge (e.g., Kenai River). These waters are frequently turquoise-colored.
HUM	Humic	Tea-colored water (tannic)
MUD	Muddy	Dark water with high suspended particulate load.

A 1-L water sample for alkalinity will be collected near the middle of the lake about 0.3 m beneath the surface immediately before leaving the lake and stored in a dark bottle and kept cool. Alkalinity samples will be refrigerated until they are analyzed in a laboratory. Prior to titration, samples will be brought to room temperature. A 100 mL sample will be titrated with sulfuric acid (0.02N) to an endpoint of pH 4.5 and the amount of titrant will be recorded (Koenig et al. 1987). Each sample will be analyzed three times and the average will be the total alkalinity.

Data Reduction and Analysis

Data collected in the field and laboratory will be transferred from field data sheets and laboratory notes into computer spreadsheets for reduction, analysis, and archiving.

Graphic profiles of temperature and dissolved oxygen will be generated using Microsoft Excel. Profiles will be inspected for readings that approach or exceed the upper and lower biological limits for stocked game fish species.

Total alkalinity (mg/L as CaCO_3) will be calculated using the following equation (Koenig et al. 1987):

$$TA = \frac{B \times N \times 50,000}{V} \quad (2)$$

where:

TA is the total alkalinity (mg/L as CaCO_3);

B is the mL of titrant (0.02N H_2SO_4);

N is the normality of the titrant;

and,

V is the sample volume.

The Secchi disk transparency (SD) is the average of the two recorded depth readings.

Reduced data from water quality sampling will be stored at the ADF&G Region III Sport Fish office and distributed to the public upon request.

BATHYMETRIC MAPS AND OTHER LAKE CHARACTERISTICS

Study Design

Selected lakes will be surveyed for bathymetry data and peripheral watershed features, such as inlets and outlets, and the main terrestrial vegetation type surrounding the lake (tree, grass, shrub). For lakes that have bathymetry data already available, perimeter mapping may be conducted to update existing files.

Sampling Methods

Position and depth data for bathymetry mapping will be collected with a *Lowrance HDS-5 Lake Insight* sonar and GPS unit. The GPS will be set to use WGS 84 to be consistent with State of Alaska databases. Latitude and longitude will be recorded in degrees to the fifth decimal.

Data Collection

Data will be collected by first following the shoreline in a small skiff within 5 m of shore where adequate depth (>0.5 m) allows. When shallow water (<0.5 m) is encountered, we will move the skiff further away from shore until there is adequate depth (>0.5 m) and mark the section on the map. Where the 0.5 m contour deviates substantially from the shore, a GPS will be used to track these sections along the lake perimeter (by either walking the shore or near shore) and depth measurements will be documented where the fathometer is unable to take readings. After surveying the shoreline the rest of the lake will be surveyed along multiple circular transects, spaced equidistance apart paralleling the shoreline and decreasing in size until the middle of the lake is reached (Figure 5).

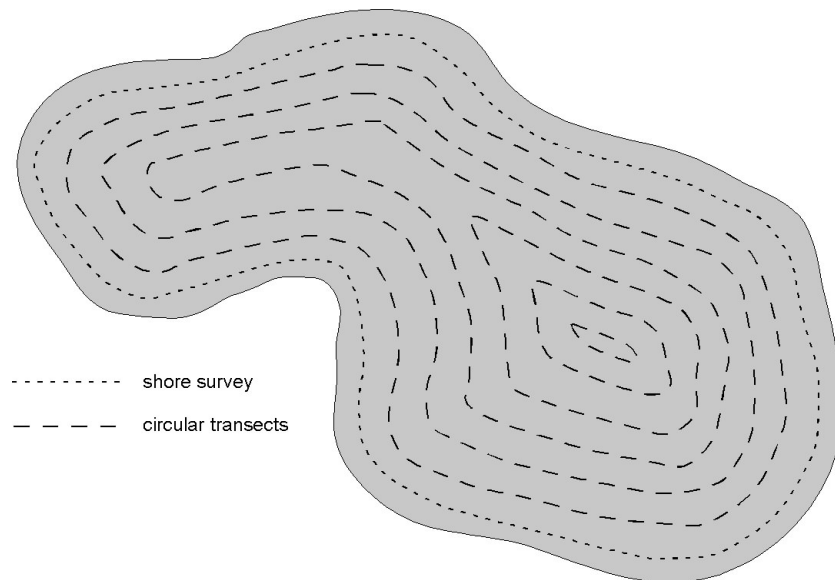


Figure 5.—Shore and circular transect pattern used to collect depth data in study lakes.

The number of transects will be determined by these guidelines: Lakes that are less than 40 ha will have a minimum of six transects; lakes between 40 and 200 ha will have a minimum of 10 transects; and, lakes that are 200 to 800 ha will have a minimum of 15 transects. If the lake bottom appears to be highly variable or “interesting,” more transects will be added after the initial transects are complete. Position and depth data are recorded every 2 seconds. This is a general design and it will be modified to conform to different lakes.

The immediate surroundings (up to 5 m from shore) of the lake will be described through visual observations. This will include documenting inlets and outlets and noting the general vegetation cover as tundra, shrub (willow), deciduous, coniferous, or a combination of these types.

At each lake, a minimum of two digital photographs will be taken: One photograph taken from the south shore looking north, and one photograph taken from the north shore looking south. Additional photographs may be taken of notable habitat features or other subjects of interest at the lake. Aerial photographs (when possible) will be taken from an altitude of 300 m above the lake and cover the entire shoreline.

Data Reduction and Map Generation

Lake maps will be generated using *ArcMap 3D Spatial Analyst*. Surface area, mean depth, max depth, volume, max length, and shoreline length will also be calculated using ArcMap.

Bathymetric maps will be added to the Alaska Lake Database (ALDAT), used to update the Division of Sport Fish’s Lake Fishing Information webpage (http://www.adfg.alaska.gov/index.cfm?adfg=fishing_Sport.region), and made available to the public at Fairbanks, Delta, and Glennallen ADF&G offices.

SCHEDULE AND DELIVERABLES

Preliminary dates for sampling, data reduction and analysis, and reporting are summarized below. Results from stocked fishery population assessments will be summarized in a FDS report containing 2011–2013 data. A draft of this report will be submitted to the Research Supervisor by March 1, 2015. Water quality data and bathymetric maps resulting from lake surveys will be summarized and filed by lake at the Fairbanks Regional Office.

Stocked Fishery Population Assessments (SFP)

Dates	Activity
1 Mar–30 April 2013	Critical period for conducting dissolved oxygen surveys (as time permits). These data will be summarized and archived in a regional database.
14 May–29 June 2013	Spring lake sampling. Actual stop time will depend on water temperature and flight availability. Fisheries to sample: Hidden Lake, Manchu Lake, Sculpin Lake, Silver Lake, Four Mile Lake, and Gergie Lake.
14 Aug–16 Aug 2013	Fall lake sampling. Actual start time will depend on water temperature. Fisheries to sample: North Twin Lake, South Twin Lake, and North Pole Pond.
15 Nov 2013	Fish, water quality, and bathymetric data summary and analysis complete. Resulting data, maps, and photos uploaded to ADF&G websites and databases.
1 March 2015	Draft FDS report summarizing stocked fishery evaluations submitted to Research Supervisor.

New Lake Evaluations (SWG)/Ambler Road Lake Surveys (DOT)

Dates	Activity
1 Mar–30 April 2013	Critical period for conducting dissolved oxygen surveys (as time permits). These data will be summarized and archived in a regional database.
22 May– Jun 2013	Spring lake sampling. Actual sample times will depend on ice out and water temperature. Lakes to sample: Skate Lake, Healy Lake, Fielding Lake, Harding Lake, and Summit Lake.
30 July–16 Aug 2013	Fall lake sampling. Actual start time will depend on water temperature and flight availability. Lakes to sample: Norutak Lake, WL730, Avaraart Lake, AR5 (Sleeper Lake), AR6, and AR7.
15 Nov 2013	Fish, water quality, and bathymetric data summary and analysis complete. Resulting data, maps, and photos uploaded to ADF&G websites and databases.
1 March 2015	Draft FDS report summarizing lake evaluations submitted to Research Supervisor.

RESPONSIBILITIES

- Cal Skaugstad:** Fishery Biologist III, Stocked Fisheries Program Supervisor.
Duties: Supervision of all aspects of projects in the Stocked Fisheries Program. Develop stocking plans for Region III and coordinate sampling schedules, data analysis, and report writing with project personnel. Supervise data analysis for stocked fishery population assessments in 2013, assist in field work, and co-author one FDS report (Management Objectives 1 and 2, Research Objectives 1 and 2).
- April Behr:** Fishery Biologist II, Stocked Fisheries Program Project Coordinator
Duties: Coordinate and lead lake sampling projects. Assign and supervise field crews, coordinate and supervise field data collection, conduct data analysis for fish population sampling, summarize water quality data, generate bathymetric maps, assist in field work, and co-author one FDS report (Management Objectives 1–4, Research Objectives 1–6).
- Kelly Mansfield:** Fishery Biologist I.
Duties: Supervise laboratory work. Assist with fish population data analysis, water quality data summaries, making bathymetric maps, and draft portions of one FDS report (Management Objectives 1–4, Research Objectives 1–6).
- Jiaqi Huang:** Biometrician II.
Duties: Provide biometric support for operational plans, data analysis, and FDS report review.
- Virgil Davis:** Technician III.
Duties: Field crew leader. Assist with field and laboratory work and data entry.
- Thomas Redington:** Technician II.
Duties: Crew member. Assist with field and laboratory work and data entry.
- Nancy Sisinyak:** Information Officer II.
Duties: Disseminate information to the public through handouts, booklets, and the ADF&G web page.

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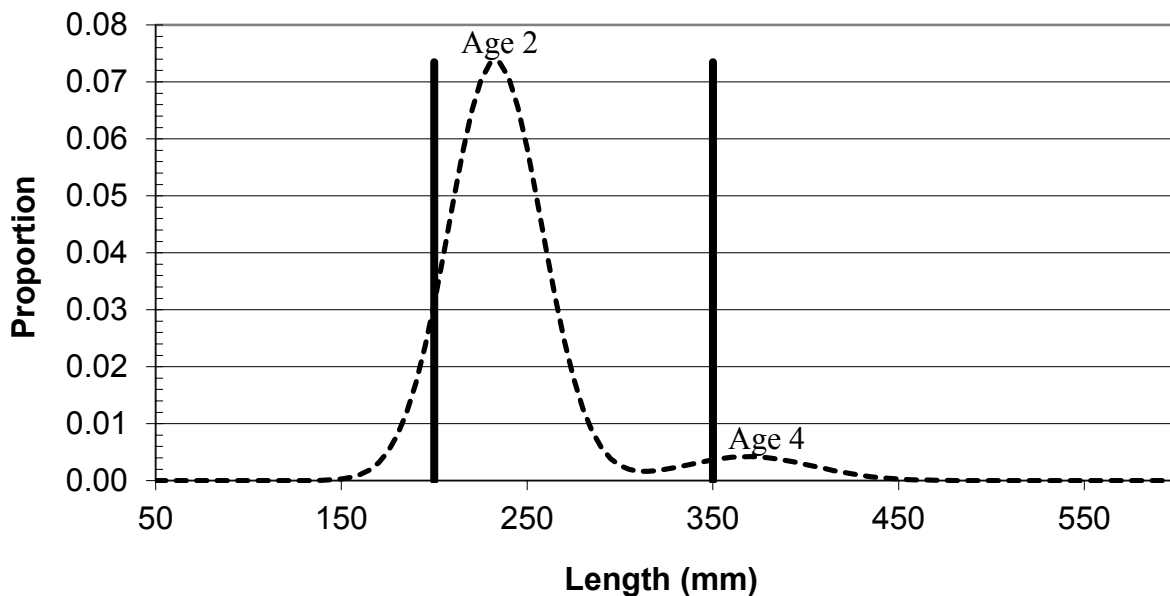
APPENDIX A
FISH POPULATION STRUCTURES BASED ON
MANAGEMENT STOCKING SCHEMES

FOUR MILE LAKE – SPRING SAMPLING

Surface Area: 40.5 hectares
 Management Category: Regional Management
 Sub-Category: Rural
 Stocking Frequency: Alternate years

Management objectives for mean length by defined length category for 2013. Mean length is based on a spring sampling date of 10 June 2013.

	$200 \text{ mm} \leq \text{RT} < 350 \text{ mm}$
Length (mm)	238



Four Mile Lake. Modeled length distribution of rainbow trout by age cohort for 2013 using a preferred stocking scheme to achieve the lake management category objectives for size composition. Actual stockings are listed in Appendix B. Vertical lines indicate the length category between 200 mm and 350 mm fish for Regional Management.

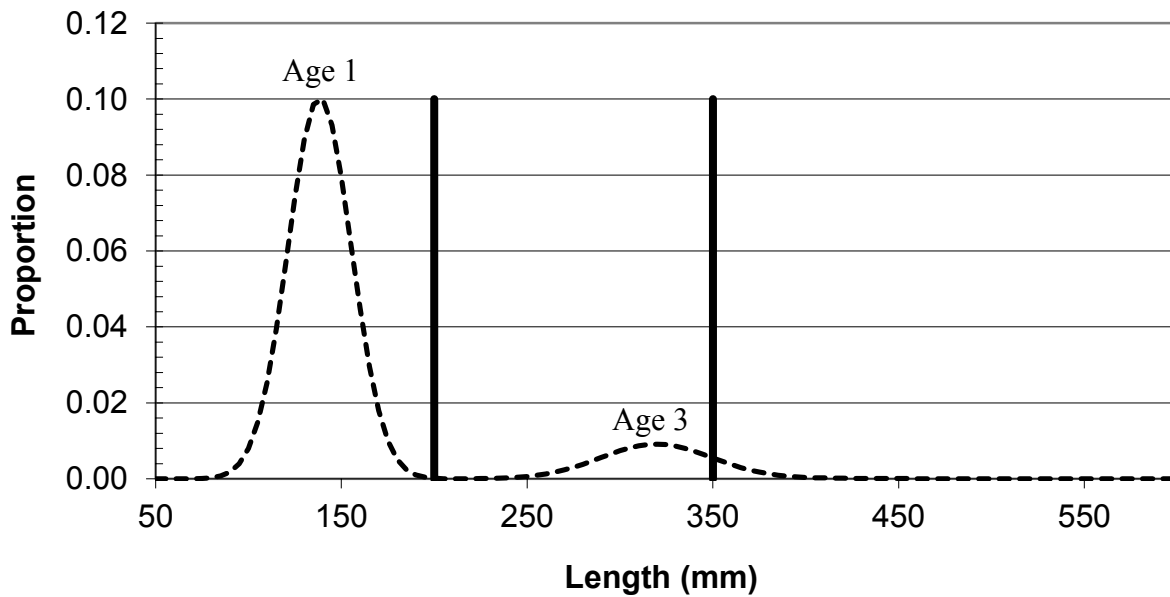
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GERGIE LAKE – SPRING SAMPLING

Surface Area: 24.3 hectares
 Management Category: Regional Management
 Sub-Category: Rural
 Stocking Frequency: Alternate years

Management objectives for mean length by defined length category for 2013. Mean length is based on a spring sampling date of 24 June 2013.

200 mm ≤ RT < 350 mm	
Length (mm)	310



Gergie Lake. Modeled length distribution of rainbow trout by age cohort for 2013 using a preferred stocking scheme to achieve the lake management category objectives for size composition. Actual stockings are listed in Appendix B. Vertical lines indicate the length category between 200 mm and 350 mm fish for Regional Management.

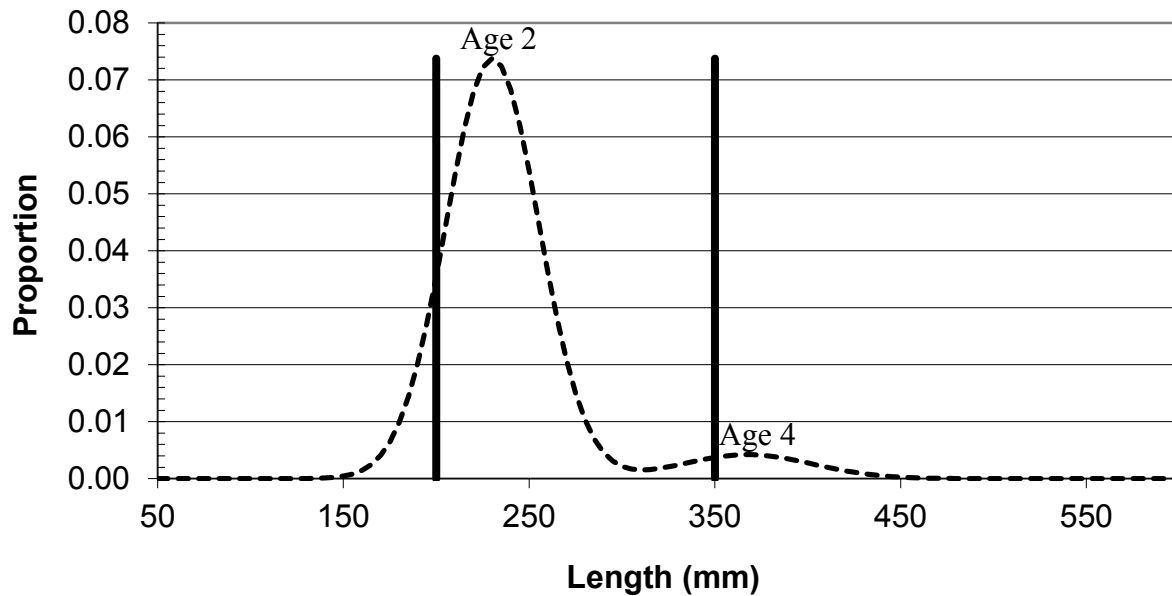
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SCULPIN LAKE – SPRING SAMPLING

Surface Area: 76.9 hectares
 Management Category: Regional Management
 Sub-Category: Rural
 Stocking Frequency: Alternate years

Management objectives for mean length by defined length category for 2013. Mean length is based on a spring sampling date of 3 June 2013.

	$200 \text{ mm} \leq \text{RT} < 350 \text{ mm}$
Length (mm)	237



Sculpin Lake. Modeled length distribution of rainbow trout by age cohort for 2013 using a preferred stocking scheme to achieve the lake management category objectives for size composition. Actual stockings are listed in Appendix B. Vertical lines indicate the length category between 200 mm and 350 mm fish for Regional Management.

APPENDIX B
STOCKING HISTORY (2007–2012) FOR LAKES TO BE SAMPLED IN 2013

Appendix B.—Stocking history (2007–2012) for lakes to be sampled in 2013.

Lake	Date	Species	Number	Average Length (mm)
Four Mile Lake	9/5/2007	AC	3219	82
Four Mile Lake	8/12/2008	RT	18000	47
Four Mile Lake	8/14/2009	AC	1575	72
Four Mile Lake	8/10/2010	RT	19809	50
Four Mile Lake	8/23/2011	AC	1600	100
Gergie Lake	8/20/2008	RT	9300	50
Gergie Lake	8/17/2010	RT	11964	51
Hidden Lake (EAFB)	5/22/2007	RT	1350	143
Hidden Lake (EAFB)	5/16/2008	RT	1100	158
Hidden Lake (EAFB)	6/10/2008	RT	900	161
Hidden Lake (EAFB)	9/3/2008	AC	711	211
Hidden Lake (EAFB)	5/15/2009	RT	1000	143
Hidden Lake (EAFB)	5/26/2009	RT	1000	138
Hidden Lake (EAFB)	5/13/2010	RT	2000	123
Hidden Lake (EAFB)	5/13/2010	AC	700	168
Hidden Lake (EAFB)	6/1/2011	AC	945	172
Hidden Lake (EAFB)	6/1/2012	AC	75	263
Hidden Lake (EAFB)	6/18/2012	RT	1800	168
Hidden Lake (EAFB)	10/4/2012	RT	3394	79
Manchu Lake	9/3/2008	AC	3200	101
Manchu Lake	8/14/2009	AC	1275	72
Manchu Lake	9/1/2009	RT	8533	52
Manchu Lake	8/23/2010	AC	1281	72
Manchu Lake	9/1/2011	AC	1275	104
Manchu Lake	6/14/2012	RT	675	183
North Pole Pond	6/7/2007	RT	1350	145
North Pole Pond	9/11/2007	KS	997	172
North Pole Pond	6/4/2008	RT	1500	157
North Pole Pond	9/10/2008	KS	1000	165
North Pole Pond	5/19/2009	AC	50	201
North Pole Pond	5/19/2009	GR	150	201
North Pole Pond	5/20/2009	AC	12	201
North Pole Pond	5/20/2009	GR	1	201
North Pole Pond	5/26/2009	RT	1500	138
North Pole Pond	8/18/2009	KS	1000	135
North Pole Pond	5/13/2010	AC	50	378
North Pole Pond	5/13/2010	RT	1500	123
North Pole Pond	5/13/2010	RT	100	343
North Pole Pond	5/24/2011	AC	9	385
North Pole Pond	5/24/2011	AC	2	463

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Lake	Date	Species	Number	Average Length (mm)
North Pole Pond	5/24/2011	AC	1	535
North Pole Pond	5/9/2012	RT	150	368
North Pole Pond	6/5/2012	RT	1690	201
North Pole Pond	6/26/2012	RT	1209	180
North Pole Pond	10/1/2012	KS	1932	210
North Twin Lake	8/14/2008	RT	2251	56
North Twin Lake	3/11/2009	LT	600	61
North Twin Lake	6/7/2010	RT	1283	85
North Twin Lake	6/20/2012	RT	603	169
Sculpin Lake	9/5/2007	RT	20000	60
Sculpin Lake	6/1/2008	RT	3000	201
Sculpin Lake	8/26/2009	RT	10000	50
Sculpin Lake	6/2/2011	RT	14246	86
Silver Lake	6/1/2007	RT	1096	69
Silver Lake	6/2/2007	RT	7046	163
Silver Lake	6/3/2007	RT	425	396
Silver Lake	6/1/2008	RT	8630	201
Silver Lake	6/1/2009	RT	8750	234
Silver Lake	8/26/2009	RT	20000	50
Silver Lake	6/1/2010	RT	7571	255
Silver Lake	6/1/2011	RT	5246	223
Silver Lake	10/3/2012	RT	15062	79
South Twin Lake	5/30/2007	RT	720	139
South Twin Lake	6/4/2008	RT	800	157
South Twin Lake	5/28/2009	RT	800	138
South Twin Lake	5/25/2010	RT	800	123
South Twin Lake	6/20/2012	RT	650	169

AC=Arctic char
GR=Arctic grayling
KS=Chinook salmon

Salvelinus alpinus
Thymallus arcticus
Oncorhynchus tshawytscha

LT=lake trout *Salvelinus namaycush*
RT=rainbow trout *Oncorhynchus mykiss*

APPENDIX C
FIELD DATA FORMS

Gear - Field Data Sheet

Alaska Department of Fish and Game

Division of Sport Fish – Stocked Fisheries Program

Lake Name: _____

Date: _____

Personnel: _____

Gear	Waypoint	Depth	Set	Pull	Water Temp (°C)

Gear Codes

FNn fyke net n net number

TNn/s tangle net* s set number

SG sport gear

*distinguish between floating (F) and sinking (S) nets

Waypoints

Save waypoints marking daily gear set locations in WGS 84 GPS datum (decimal degrees to the fifth decimal). Mark waypoints on a new bathymetric map each day.

Depth

Measure the water depth (m or ft) at each set location using a hand held depth instrument.

Set and Pull Time

Record date (MM/DD) and time (military time) for each gear set and pull.

Temperature

When each net is SET record water temperature (to the nearest 0.10°C) 1 m below the surface at each set location.

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Water Quality - Field Data Sheet*Alaska Department of Fish and Game**Division of Sport Fish – Stocked Fisheries Program*

Location: _____ Station #: _____ Way Point: _____

Date: _____ Time: _____

Personnel: _____

Weather/Cloud Cover: _____

Air Temperature (°C): _____ Secchi Depth: Disappear (m): _____

Snow Cover (cm): _____ Reappear (m): _____

Ice Thickness (cm): _____ Alkalinity Sample Time: _____

Depth (M)	Bar Pres	Temp C	D.O.	%D.O.	SP Cond	pH	TDS	ORP
0								
0.5								
1								
1.5								
2								
2.5								
3								
3.5								
4								
4.5								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
Max Depth								

Lake Type

_____ glacial
 _____ organically stained
 _____ clear-water

Water Color

_____ clear
 _____ ferric
 _____ glacial-high turbidity
 _____ glacial-low turbidity
 _____ humic
 _____ muddy

Pictures (at least 2; mark when done)

_____ From South Shore
 _____ From North Shore
 _____ Trails (if any)

Notes:

APPENDIX D

ASSUMPTIONS AND BIAS

An accurate estimate of a population length frequency distribution requires that all fish in a population have the same probability of capture. In practice this likely does not happen and this assumption cannot be evaluated with a single-sample capture-event. However, a review of the literature and previous mark recapture studies conducted by ADF&G indicates that potential bias may be minimized by avoiding sampling activities when water temperatures are high, by sampling different habitat areas, and by using gear that is not size selective.

Researchers have found that water temperature influences rainbow trout distribution in lake systems, and have documented movement of rainbow trout from nearshore to offshore habitats when water temperature exceeds 20°C (Horak and Tanner 1964; Overholtz et al. 1977; Rowe and Chisnall 1995; Rowe 1984). Doxey (1989, 1992; M. Doxey, Sport Fish Biologist, Retired, ADF&G, Fairbanks; personnel communication) noted an influx of rainbow trout to shallow, nearshore areas as water temperature dropped during fall sampling activities conducted at Birch Lake, Alaska. Researchers have also noted that rainbow trout preferred depths of 0-4 m in the spring, and avoided shallow water as temperature increased throughout the summer (Overholtz et al. 1977). Additionally, a study conducted by Kwain and McCauley (1978) found that older rainbow trout have a lower temperature preference than do younger fish. Based on these findings, we conclude that larger fish will likely be the first to seek thermal refuge offshore as water temperature in littoral areas increases. To minimize the potential for size bias sampling due to this phenomenon, all sampling during our study will be conducted when water temperature 1 m beneath the surface is < 18°C.

Although we expect rainbow trout populations to be distributed nearshore when water temperature is < 18°C, we will sample both nearshore and offshore habitats to verify the presence or absence of fish in both areas. Previous studies conducted by ADF&G (under similar thermal conditions) found that capture rates for rainbow trout in offshore tangle nets, fyke nets, and hoop traps were lower than those for nearshore fyke nets (Fish and Skaugstad 2004; Havens et al. 1992; Behr and Skaugstad 2007). Warner and Quinn (1995) found that radio-tagged rainbow trout in Lake Washington were predominantly found in nearshore areas and resided in the top 3 m of the water column 90% of the time during sampling conducted in June, August, September, and October. Similarly, approximately 88% of all rainbow trout caught during sampling activities in 2005 were captured in nearshore fyke nets (Behr and Skaugstad 2007).

To minimize the potential for size bias due to capture gear we will use fyke nets and 13 mm bar, fine thread, monofilament tangle nets during our study. Fyke nets are typically fished in shallow waters and have proven effective at catching rainbow trout 50mm to 600 mm (Behr and Skaugstad 2006; Fish and Skaugstad 2004). The length of fish captured in tangle nets is variable and depends on mesh size; however, a 13 mm mesh should be sufficient to capture age-1 and older fish in stocked lakes.

The sampling methods used in this study are similar to those used in previous two-sample mark-recapture experiments conducted by ADF&G in which size bias was examined using either Kolmogorov-Smirnov (K-S) tests (Conover 1980) or chi-square contingency table analysis (Seber 1982). Robust and objective evaluation of size biased sampling is problematic, at best, when fish grow between sampling events. In Interior Alaska, average growth rates of nearly 1 mm per day have been observed for rainbow trout during summer (Doxey 1989).

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We reviewed several previous experiments to evaluate the relation between detected size bias during rainbow trout sampling and water temperature. In two-sample experiments where a hiatus of more than two weeks occurred between sampling events (allowing for substantial growth), we reanalyzed experimental data using methods described in Behr and Skaugstad (2006), where unambiguous testing for size bias could only be conducted for first event sampling. In other experiments, where necessary, data were reanalyzed to test for size bias during both sampling events using methods described in Behr et al. (2005). These results may differ from published results in some cases, as we analyzed size data from all rainbow trout captured during these experiments, not just the target age classes.

In 2004, two mark-recapture experiments were conducted at Koole and Rainbow lakes to estimate the abundance of rainbow trout. Sampling procedures for both experiments were similar to those for this study, except that hook-and-line gear was used to supplement catches at both lakes and hoop nets were used at Rainbow Lake. K-S test results indicated that no significant size bias occurred during the first sampling event at Koole Lake, where the maximum water temperature recorded was 14°C at a depth of 0.3m during June 7–11. Similarly, no significant size bias was detected for the first sampling event at Rainbow Lake where the highest water temperature recorded was 17.7°C at a depth of 0.5m on August 25 (Behr and Skaugstad 2006). During Events 1 and 2, 97% and 99% of samples, respectively, were caught in fyke traps. Age-0 rainbow trout that were stocked in Rainbow Lake prior to sampling and subsequently captured in fyke nets were not used in mark-recapture experiment. Usually the smallest age-0 fish can escape through the fyke net mesh and they are subject to predation by larger fish in the fyke nets. This situation will likely result in an observed probability of capture that is significantly different from that for the other age cohorts. Consequently, age-0 fish are enumerated and measured during population sampling but the data are not used to generate information about population structure.

Only near shore fyke nets were used during a two-sample mark-recapture experiment conducted in mid-June and mid-August of 2001 at Lisa Lake. K-S test results indicated that size bias for rainbow trout captured during the first event was not significant (Behr et al. 2005). Water temperature during mid-June was 17.5°C 1 m beneath the surface. In September and October of 2006 a second mark-recapture experiment was performed at Lisa Lake. Offshore tangle nets and nearshore fyke nets were used during both events, and K-S test results indicated that no significant size bias occurred (Behr and Skaugstad 2007). Water temperatures at 1 m beneath the surface were 11.1°C during Event 1 and 5.5° during Event 2.

In 2000, four two-sample mark-recapture experiments were conducted at Dune, Bluff Cabin, Donna, and Little Donna lakes (Skaugstad and Fish 2002). Fyke nets, tangle nets, and hook-and-line gear were used. Sampling was conducted in June and August. Reanalysis of rainbow trout mark-recapture data for Dune Lake provided no significant evidence of size bias sampling during Event 1 ($p = 0.972$) where the water temperature was 16.3°C at a depth of 1.0 m on June 15 (the last day of sampling). Reanalysis of Donna Lake data provided no significant evidence of size bias sampling during either Event 1 ($p = 0.196$) or Event 2 ($p = 0.772$). Water temperature was

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about 10.5°C at a depth of 1 m on August 31 (first day of Event 2 sampling). Similar results were obtained from data from Little Donna Lake for both Event 1 ($p = 0.425$) and Event 2 ($p = 0.978$). While sampling at Little Donna Lake occurred during the same time frame as at Donna Lake, no water temperature data were available. In contrast, reanalysis of Bluff Cabin Lake data indicated significant size bias sampling during both Event 1 ($p < 0.001$) and Event 2 ($p = 0.001$) where the water temperature was 17.2°C at a depth of 1.0 m and 18.6°C at a depth of 0.5 m on 6 June (the first day of sampling).

Two-sample mark-recapture experiments were performed at Quartz Lake in 2001 to estimate the abundance of age-1 rainbow trout and in 2002 to estimate the abundance of age-2 and older rainbow trout (Fish and Skaugstad 2004). Nearshore and offshore fyke nets, hoop nets, and tangle nets were used in 2001 and sampling was conducted May 29 to June 1 (Event 1) and June 18 to 22 (Event 2). Reanalysis of these data indicated significant size bias sampling during both Event 1 ($p < 0.001$) and Event 2 ($p < 0.001$) where the water temperature was 11°C at a depth of 1 m on May 31 and 20°C at a depth of 1 m on June 22. Less than 1% of the rainbow trout were caught in floating fyke nets, hoop nets, and tangle nets deployed in water > 1 m in depth. In 2002, fyke nets and tangle nets were used and sampling was conducted in September. Reanalysis provided no significant evidence of size bias sampling during either Event 1 ($p = 0.384$) or Event 2 ($p = 0.493$). Water temperature was not recorded during sampling but typically lake temperatures have cooled to $< 14^\circ\text{C}$ by September. Rainbow Lake (16 km from Quartz Lake) was $< 12^\circ\text{C}$ 1 m below the surface in mid-September. During Event 1 no rainbow trout were caught in tangle nets in deep water and during Event 2 sixteen percent of the fish sampled were caught in tangle nets. The size distributions of fish captured with all gear types during Event 1 and Event 2 were not statistically different ($p = 0.734$).

Of the studies reviewed, only one result was inconsistent with our prescription to restrict sampling to when water temperature is $< 18^\circ\text{C}$ in order to minimize potential for size biased sampling of rainbow trout. Significant size bias sampling was detected during Event 1 sampling at Quartz Lake in 2001, when water temperatures was 11°C. Probability of capture of rainbow trout 170 mm and larger (age 2 and older) was greater than that of smaller rainbow trout (age-1). During Event 1 the larger rainbow trout were concentrated in a few nearshore areas for spawning and later, during the hiatus and Event 2, dispersed throughout the lake (Fish and Skaugstad 2004). Researchers realized that spawning behavior in spring would likely affect the capture probability of age-2 and older rainbow trout during the course of the study; however, they were interested only in estimating the abundance of age-1 rainbow trout. Future studies of the Quartz Lake rainbow trout population using single-sample methods to estimate relative abundance should be conducted in fall to avoid capture heterogeneity between different size/age cohorts.

Detecting capture heterogeneity when sampling small populations ($< 2,000$ fish) is very difficult. The K-S test is typically used during two-sample mark-recapture experiments to detect size bias sampling during either sampling event and to guide model selection for estimating abundance and composition. To estimate the power of the K-S test to detect size bias sampling in small populations, we constructed artificial populations of two age classes (age-1 and 2) of rainbow trout based on length-at-age data from previous experiments (ADF&G, *Unpublished*, available from the authors). Population size varied from 500 to 2,000 fish, and within each population the

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proportion of age-2 fish was varied from 20% to 66%. We then simulated two-event mark-recapture sampling on these populations with sufficient sampling intensity to estimate abundance within 20% of the true value 95% of the time (assuming no size bias during sampling). We simulated probability of capture for age-2 fish to be 50% of the probability of capture of age-1 fish during both sampling events, and also simulated this size bias sampling during only Event 1 with no size bias during Event 2. We conducted K-S tests to detect capture heterogeneity and estimated power by evaluating the frequency when size bias sampling was concluded. The results from capture heterogeneity during both events and during Event 1 are reported in Table 5 and Table 6, respectively. When capture heterogeneity was simulated during both sampling events, the power of the K-S tests was poor ($< 1\%$ to 30%) when the segment of the population with lower capture probability comprised 50% or less of the population when using $\alpha = 0.05$ as the rejection criteria for the test. When $\alpha = 0.20$ was used as the rejection criteria, power was still poor ($< 1\%$ to 26%) when the segment of the population with lower capture probability comprised 33% or less of the population. In simulations where capture heterogeneity occurred only during Event 1, the power of the K-S test was poor ($< 1\%$ to 29%) when the segment of the population with lower capture probability comprised 33% or less of the population when using $\alpha = 0.05$ as the rejection criteria. When $\alpha = 0.20$ was used as the rejection criteria, power was still poor ($< 9\%$ to 23%) when the segment of the population with lower capture probability comprised 20% or less of the population.

The levels of capture heterogeneity sufficient to cause concern when interpreting composition proportions (detecting large fish 50% as often as smaller fish) are not likely to be detected during reasonably well designed two-sample experiments on small populations with age structures similar to what are usually encountered. The fairly poor power of widely used diagnostics tests under these conditions emphasizes the need to identify the field conditions where the chances of size bias sampling occurring can be minimized.

For our studies, the bias introduced by unequal capture probabilities for the different length-age cohorts has different effects on estimating length frequency mode location and mode amplitude. Mode location is important for determining the mean length of length-age cohorts while mode amplitude is important for determining the relative abundance of the length-age cohorts in the population. The bias caused by unequal capture probabilities when estimating mode location will be minimal when individuals in each length-age cohort have the same capture probability (i.e., capture probabilities are the same within cohorts but may be different between cohorts).

Bias will likely have a greater influence on estimating mode amplitude and, thus, on estimating proportions of fish in different length-age categories (i.e., relative abundance). As such, analysis of relative abundance is no longer performed; however, this bias could still affect mean values within specified length categories because multiple age cohorts are often present in a specified length category. Different capture probabilities between length-age cohorts will result in catches that are not representative of cohort abundance in the population. Increasing the sample size will make the modes more prominent but it will not improve the accuracy of the estimate. However, our review of other studies has shown that the likelihood of size bias is low when sampling is restricted to periods when water temperature is $< 18^{\circ}\text{C}$. It is anticipated that two-sample mark-

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recapture studies will be conducted periodically for the larger lakes which are stocked on an annual basis and support a number of age cohorts. We will continue to use information from these studies to evaluate potential size bias associated with single-capture sampling.

Table 5.–Power of Kolmogorov-Smirnov (K-S) test to detect capture heterogeneity in small populations during two-sample mark-recapture studies designed to estimate true abundance within 20% of the true value 95% of the time, where $x\%$ of the population has 50% of the capture probability of the remainder of the population during both sampling events. Results based on 10,000 simulations of two age classes of fish with adjacent but non-overlapping bell shaped length distributions and $x\%$ represents one entire age class.

N	$x\%$	Mean		Power of RvC & MvC K-S tests		
		M & C	R	$\alpha = 0.05$	$\alpha = 0.10$	$\alpha = 0.20$
500	0.20	157	52	<0.01	<0.01	0.02
750	0.20	204	58	<0.01	<0.01	0.03
1,000	0.20	245	63	<0.01	0.01	0.04
1,500	0.20	313	69	<0.01	0.02	0.05
2,000	0.20	372	73	<0.01	0.02	0.06
500	0.33	158	54	<0.01	0.03	0.08
750	0.33	205	60	0.02	0.05	0.13
1,000	0.33	244	64	0.02	0.06	0.16
1,500	0.33	313	71	0.03	0.09	0.21
2,000	0.33	373	75	0.05	0.12	0.26
500	0.50	157	55	0.08	0.19	0.37
750	0.50	204	62	0.14	0.27	0.46
1,000	0.50	244	66	0.19	0.33	0.53
1,500	0.50	313	73	0.26	0.42	0.61
2,000	0.50	371	76	0.30	0.46	0.65
500	0.66	157	56	0.26	0.43	0.61
750	0.66	205	63	0.36	0.53	0.70
1,000	0.66	245	67	0.44	0.61	0.76
1,500	0.66	314	74	0.54	0.69	0.81
2,000	0.66	372	78	0.59	0.73	0.84

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Table 6.–Power of Kolmogorov-Smirnov (K-S) test to detect capture heterogeneity in small populations during two-sample mark-recapture studies designed to estimate true abundance within 20% of the true value 95% of the time, where $x\%$ of the population has 50% of the capture probability of the remainder of the population during first event sampling and no capture heterogeneity occurs during second event sampling. Results based on 10,000 simulations of two age classes of fish with adjacent but non-overlapping bell shaped length distributions and $x\%$ represents one entire age class.

N	$x\%$	Mean		Power of RvC K-S test		
		M & C	R	$\alpha = 0.05$	$\alpha = 0.10$	$\alpha = 0.20$
500	0.20	157	49	<0.01	0.03	0.09
750	0.20	204	56	0.01	0.04	0.13
1,000	0.20	245	60	0.02	0.06	0.16
1,500	0.20	313	65	0.03	0.09	0.21
2,000	0.20	373	69	0.04	0.11	0.23
500	0.33	158	50	0.08	0.18	0.35
750	0.33	205	56	0.12	0.25	0.43
1,000	0.33	244	59	0.17	0.32	0.49
1,500	0.33	313	65	0.24	0.39	0.57
2,000	0.33	373	70	0.29	0.44	0.61
500	0.50	157	49	0.24	0.39	0.57
750	0.50	204	55	0.34	0.49	0.67
1,000	0.50	244	60	0.40	0.55	0.71
1,500	0.50	313	65	0.48	0.63	0.77
2,000	0.50	371	69	0.53	0.67	0.80
500	0.66	158	50	0.24	0.39	0.57
750	0.66	204	56	0.34	0.50	0.66
1,000	0.66	244	60	0.39	0.55	0.70
1,500	0.66	314	65	0.48	0.63	0.77
2,000	0.66	372	69	0.53	0.67	0.80